HOQUIAM RIVER BRIDGE
(Simpson Avenue Bridge)
U.S. Route 101 (Simpson Avenue) spanning the
Hoquiam River
Hoquiam
Grays Harbor County
Washington

HAER No. WA-93

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WRITTEN HISTORICAL AND DESCRIPTIVE DATA

PHOTOGRAPHS

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
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HOQUIAM RIVER BRIDGE
(Simpson Avenue Bridge)

HAER No. WA-93

Location:	U.S. Route 101 (Simpson Avenue) spanning the Hoquiam River, Hoquiam, Grays Harbor County, Washington, beginning at mile point 87.76. UTM: 10/433400/5202590 Quad: Hoquiam, Washington
Date of Construction:	1928
Engineer:	Washington Department of Highways. Strauss Bascule Bridge Company of Chicago, consulting engineers.
Fabricator:	Wallace Bridge and Structural Steel Co.of Seattle, steel. General Electric provided the electrical equipment. Puget Sound Bridge and Dredging Co. of Seattle, general contractor.
Owner:	City of Hoquiam. In 1935, bought by the Washington Department of Highways. Since 1977, the Washington State Department of Transportation, Olympia, Washington
Present Use:	Vehicular and pedestrian traffic.
Significance:	The central span is an example of a patented double-leaf Strauss underneath counterweight bascule bridge. The Strauss Bascule Bridge Company was one of the most important bridge building firms in the United State during the early 20th century. The contractors, Puget Sound Bridge and Dredging Company, was a significant engineering and construction firm in the Northwest. The bridge has been placed on the National Register of Historic Places.
Historian:	Wm. Michael Lawrence, August 1993

History of the Bridge

The twin cities of Wishkah and Hoquiam are located on a low-lying flatland at the head of Gray's Harbor on the Pacific Coast. They once were bustling harbor towns, whose fortunes depended greatly on the lumber industry. Captain A. M. Simpson, a pioneer Pacific Coast mariner and lumberman, provided the financial backing for the Northwestern Mill, which along with the National Mill, stood next to the site of the Hoquiam River Bridge. He never resided in Hoquiam, but the city named the one of its streets after him. Simpson Avenue would one day cross the Hoquiam River by means of a new bridge, built in 1928.[1]

The Hoquiam River is one of several which flow through the twin cities and which have been used in the past to dock ships. Low banks meant that only a bridge set on high approaches or one with a through-truss span could provide clearance for ships. The city of Hoquiam and the Washington Department of Highways chose to build a bascule bridge with high approaches, to permit all but the tallest ships to go under it without opening the leaves and to raise Simpson Avenue above a railway and the yard of Northwestern Mill.

The people of Hoquiam had waited a long time for the bridge. At the formal dedication of the structure on 11 May 1928, Congressman Albert Johnson would recall how in 1910, as editor for the *Washingtonian,* he helped launch the movement for "the great bridge." It took 18 years for it became a reality.[2]

The *Pacific Builder and Engineer*, a major contractors' journal in the Northwest, published a series of brief reports concerning the bridge, tracing some of the events leading to its construction. In 1922, the state and the city of Hoquiam considered building a bridge over the Hoquiam River. On 3 November 1922, the journal reported that an engineer from the state highway department was to make a survey for such a bridge, anticipating that such a structure might be necessary in the future.[3] The following July, M. M. Caldwell of Seattle was chosen to design a bridge for the Simpson Avenue crossing and to make cost estimates.[4] Caldwell proposed a structure with a long elevated approach to span the tracks and mill yards, at a cost of $300,000.[5] The design went through a number of changes as it was developed. At one point the city council considered a single leaf bascule, but in March 1924, Mayor H. B. Fischer announced that the bridge would have a double leaf bascule, with a 28' roadway, at a cost of $375,000.[6]

It would be some time before the project would proceed to the construction phase. In August 1926, the city council deferred to State Highway Engineer J. Webster Hoover to oversee the project.[7]

The state and the city agreed to share the cost, with the city purchasing the necessary land.[8]

By the following January, the *Pacific Builder and Engineer* reported that the engineers were still working on the plans, but they expected to award the contract before 1 March 1927. The Strauss Bascule Bridge Company, as consulting engineers, prepared the drawings and specifications for the bascule span and its substructure.[9] The estimated cost was $350,000. The State Highway Department agreed to pay $100,000 of this amount.[10] The department did make the official call for bids, with a copy appearing in the *Pacific Builder and Engineer* on 12 February 1927, but the contract would not be awarded before 1 March. The deadline for submitting bids was set for 8 March.[11]

Puget Sound Bridge and Dredging Company of Seattle, one of the Pacific Northwest's leading engineering and construction firms, was the low bidder at $349,569.[12] Work began on 25 March and the contractor completed the bridge nearly sixteen months later, on 20 July 1928.[13] The Wallace Bridge and Structural Steel Co. of Seattle fabricated the steel and General Electric provided the electrical equipment.[14]

Apparently, the bridge was substantially complete by 11 May 1928, for on that day it was formally dedicated, at 11 a.m. Businesses closed and schools suspended classes. City officials led by Mayor George Brault drove to the city limits to meet Governor Roland H. Hartley and his party from Olympia. They formed a parade, led by the Aberdeen High School Band, and proceeded to the bridge.

A huge crowd waited, standing along the river banks. As the procession approached the new structure, the double-leaves were raised to the full open position while river craft blew their whistles and the two mills ran their sirens. The procession split, with the governor's party driving up the east approach, and the mayor's group driving around to the other side of the river at the Eighth Street bridge and then up the west approaches of the new Simpson Avenue bridge.

At a prearranged signal, the leaves lowered slowly. Mayor Brault and Governor Hartley walked to the center of the span, shook hands over a ribbon stretching across the roadway, then cut it. The crowds cheered and airplanes flew overhead, dropping flowers on the structure. The mayor and the governor both drove their cars across, followed by hundreds of automobiles owned by local citizens who had waited so long for this moment.[15]

Today the nearby mills are gone. The bridge rises high above weeds that grow in the empty lumber yards, but it still serves as part of a major street through the cities of Aberdeen and Hoquiam. The structure has been placed on the National Register of Historic Places.

Design and Description

The movable part of the Hoquiam River or Simpson Avenue bridge is an example of the Strauss underneath counterweight trunnion bascule span type. A main trunnion supports the leaf and a counterweight hangs from a trunnion at the heel of the leaf truss. A link connects the counterweight to the substructure supporting the main trunnions. The two trunnions and the pins at each end of the link are at the four points of a parallelogram which changes its configuration as the leaf moves up and down. This arrangement assures that the moments created by the counterweight and the leaf about the main trunnion are equal but opposite. With this, the mass of the counterweight balances that of the leaf, making it easy to move the span.

The bascule bridge is part of a larger structure, which may be described briefly. Four different kinds of structures are combined in this bridge. The approaches, standing mostly over dry land, consist of concrete decks on timber bents, concrete girders on concrete piers and steel trusses on concrete piers. The west approach is 969 feet long and consists of 32 15′ -6" timber trestle spans; 2 21′ timber trestle spans; 14 15′ -6" timber trestle spans; one 64′ -1/2" concrete girder span; and one 149′ -11" Pratt through truss span. The east approach is 760 feet long and consists of 33 15′ -6" timber trestle spans; 2 64′ - 1/2" concrete girder spans; and one 120′ Warren through truss span. The bascule piers, on either side of the main channel, contain the bascule counterweights and machinery, and are constructed of reinforced-concrete.[16] These structures, combined with the bascule bridge which spans the channel at the center of the river, are a rather curious-looking combination, in that they lack the sort of visual unity or harmony that many consider the essence of beauty. But there is a logic in the arrangement, in that it puts structures that can span longer distances over the waterway, where constructing piers is more expensive.

The bridge over the channel is a two-leaf bascule with a span of 200′-6" at the trunnions. The distance between each trunnion and the bearing point of the nearest Pratt truss is 21′-6". The leaves are supported by steel columns inside the two concrete piers, which also house the counterweight and machinery. These piers rest on piles driven deep below the river bed. The clear distance between the piers is 173′. At high tide, the vertical clearance under the bridge is 36′ at its center.[17]

The roadway supported by the bascule, which originally was of wood, is 20' wide and is flanked with 5' sidewalks which cantilever beyond the trusses. These are Pratt half-through trusses, with curved lower chords, spaced 24' apart from center to center and constructed of riveted members. As the truss and counterweight are balanced at the main trunnion, this pivot point carries the dead load of the floor, truss, and counterweight. When the leaves are closed, they rest on bearing shoes below and in front of the trunnions. A stress drawing for the trusses refers to these as "live load supports."[18] They carry part of the loads from vehicles or pedestrians on the leaf.[19]

The 400,000 pound reinforced concrete counterweight[20] balances the weight of the leaf, making it possible to move it with a minimum of power. It hangs from a pivot point at the heel of each leaf truss, the counterweight trunnion. It is connected by a link from a pin near its bottom to another pin at the substructure which supports the trunnions. The configuration between the four pivot points -- the trunnion, the counterweight pin, and the two link pins -- is that of a parallelogram throughout the entire movement of the leaf (fig. 1).

The purpose of this arrangement is to keep the center of gravity of the counterweight directly below its trunnion, at the heel of the truss, at all times. This assures that the moment about the counterweight trunnion will be constant, at 0 kip-feet. With this, the moment around the main trunnion created by the counterweight, which is a product of the load and the distance between the counterweight's center of gravity and the main trunnion, will be equal but opposite to the moment created by the leaf, through the entire operation of the bascule. Or, to put it another way, without the counterweight link, the counterweight might begin to swing back on its trunnion. Because of its great mass, it could easily damage the trunnions, substructure, and the machinery which moves the leaves.[21]

This parallelogram configuration is typical of most Strauss bascule bridges. Some engineers have considered this to be a variation of the first Strauss bascule bridge design, the overhead counterweight trunnion type (fig. 2). In this type, the counterweight is above the its trunnion, the pivot point being located at the heel of the truss, pushing rather than pulling down on the heel. A tower extends high above the main trunnion. The counterweight link, with pins at each end, connects the top of the counterweight with the top of the tower. In this bascule type, the parallelogram arrangement of trunnions and pins extends above the deck rather than below it. The effect is the same as with the underneath counterweight type. The configuration keeps the center of gravity of the counterweight vertically aligned with its trunnion at all times, so that its moment around the main trunnion will always counteract that of the leaf.[22] Should the counterweight link fail the great mass of concrete will swing down onto the roadway, with results as undesirable, if not more so, than a similar failure in the underneath counterweight arrangement.

This delicate balance of masses would be useless, however, without some means of moving them. This consists of a series of gears and shafts driven by electric motors, with smaller gears driving larger ones, giving the motors a mechanical advantage. A convex rack, with a 14' 6" radius measured from the main trunnion, is built onto each truss, below that centerpoint. The operating pinion's teeth engages those of the rack and drives it, moving the bridge. The pinion in turn, is driven by a shaft, supported by bearings flanking the pinion (fig. 3). A large gear on the end of the shaft, inside the machinery room, turns this shaft. This gear, in turn, is driven by a smaller gear on the end of a long shaft which extends all the way across the machinery room. This long shaft drives an identical arrangement, with gears, a shaft, an operating pinion, and a rack, at its other end. The long shaft is driven by a series of reduction gears at its center, and, ultimately, by two electric motors. Electric solenoid brakes, at the two ends of one of the shafts in the reduction gear assembly, can stop all motion.[23] Most of this machinery is housed within a sheet metal building tucked within the concrete tower, below the main trunnions.

The two center locks are significant, for they exemplify a Strauss invention used in many of the company's double-leaf bascule bridges (fig. 4). Each lock is located at one of the gaps between the trusses of each leaf. It consists of a pair of cast steel jaws, mounted on the west truss, which engage seats within a 1" high cast steel mouth, built into the end of the east truss. At its tail, each jaw is connected to the truss by means of a pin. The two jaws overlap each other at their heads. A pin passes through a slot in each head, creating a toggle joint. When the lock is closed, the jaws fit into the mouth, engaging seats at the top and bottom of the mouth. A flexible link connects the head of one of the jaws with the truss. When it is straightened and bent, it pushes the jaws into and out of the mouth. The links are moved from below by a push rod, which in turn is moved up and down by a crank turned by a series of reduction gears. An electric motor at the south side of the west leaf powers the locking mechanism on both sides of the leaf, the north lock directly and the south lock by means of a shaft. A hand-crank can substitute for the motor.[24]

The Strauss company invented the lock and patented it several years before designing the Hoquiam River Bridge. They first used it at the State Street Bridge in Racine, Wisconsin, in 1922. In

1923, Philip L. Kaufman, of that company, contributed an article concerning the lock to the *Engineering News-Record*. He claimed that the device was superior to the standard locking system, a plunger sliding back and forth into a slot. The jaws could help the bridge tender align the leaves and, since they moved away from the seats in the mouth when disengaging, the jaws and mouth would not wear out from friction.[25] This has been true with the lock at the Hoquiam River bridge. The jaws and locks have never worn out. The pins and their bushings did, however, and the Washington Department of Highways had to replace them in 1967.[26]

There are several safety features built into this bridge. A limit switch at the operating pinion stops the motors when the bridge is almost closed or fully opened, preventing damage. A similar switch at the center locks stops its motor if the mechanism begins to exceed its path of travel. The electrical solenoid brakes automatically close if electrical power is shut off, stopping the motion of the bridge. Gates at either end of the bascule span lower to warn vehicle drivers and pedestrians when the bridge is going to open. The bridge tender operates all this machinery from a control room, built into the top of the through truss just west of the bascule span.

Some engineers have pointed out that, because the counterweight and machinery can be concealed within the towers or piers below, this sort of bridge can be quite attractive when closed.[27] This is especially true if the towers are made to appear like masonry or if they are ornamented. This is not the case with the Hoquiam bridge, for the counterweight hangs out the back of the towers and the designers left the concrete unfinished. Perhaps the site of this bridge, in a gritty, hard-working, bustling harbor town, justified its rude appearance when it was constructed. The disadvantage of this type of bridge is quite obvious: the need for long, high approaches or perhaps, a counterweight pit below the water level.

A discussion of this bridge would be incomplete without considering it in its context, the development of the Strauss bascule bridge types. As already stated, the underneath counterweight type was considered a variation of the overhead counterweight type. The first Strauss bascule type ever built, a bridge completed in 1905 for the Wheeling and Lake Erie Railroad over the Cuyahoga River, in Cleveland, Ohio, was an overhead counterweight type.[28] The Wishkah River Bridge (HAER No. WA-92), a few miles away from the Hoquiam River Bridge, is an example of another Strauss type derived from the overhead counterweight type and developed around 1910, the "heel trunnion bascule type." The underneath counterweight type may have been developed about the same time. An illustration in a Strauss patent application, filed for in 1908, depicts a counterweight hanging by a pivot at the heel of the truss and rack and pinion arrangement quite similar to the Hoquiam River Bridge's configuration.[29] Most Strauss movable bridge spans, including some vertical lift bridges, employed the parallelogram arrangement of trunnions and pins found in these three types. By 1927, when the Hoquiam River or Simpson Avenue bridge was being designed, the Strauss Bascule Bridge Company had built more movable bridges than any other concern, 267 in all.[30]

Repair and Maintenance

The Hoquiam River Bridge is a large, complex structure, consisting of timber trestles, reinforced-concrete decks, girders and piers, steel trusses, and a bascule span which is moved by means of complicated machinery and electrical systems. Because it is part of one of the main streets through Hoquiam and Aberdeen, as well as part of a highway used by tourists visiting the Pacific coast, it carries a heavy traffic load. It is not surprising that it presents maintenance personnel with a variety of problems.

The timber trestles rot and state highway personnel have to replace stringers and cross bracing periodically. Many of the piles have cracked and rotted out inside. Eventually, the approaches will have to be replaced in their entirety.

By 1952, the reinforced concrete deck deteriorated to the point where 2" asphalt overlay was placed over it. Reinforced concrete encases the steel columns supporting the trunnions and live load bearing plates, presumably to protect them from salt water. It has trapped moisture inside and rusts the steel members. Repairs will be difficult.

The 20'-wide roadway is too narrow for today's traffic. On occasions, a vehicle will damage parts of the bridge, as in 1984, when an automobile went out of control, crossed a sidewalk along one of the approaches, and destroyed part of the concrete railing.

The through trusses are particularly vulnerable to accidents. The vertical clearance at the portals is only 14'-6." Logging trucks and equipment haulers damage the lateral overhead bracing about 3 times per year. This requires straightening using heat processes. In addition, such steel members can easily rust, and need periodic repainting. The Hoquiam River Bridge's steel members receive a new coat of paint every ten years, on the average.

The highway department replaced the original wooden deck at the bascule spans with an open steel grid in 1948. This was a typical retrofit for bascule bridges during the 1930s and 1940s, and extended the life of many of these structures despite increasing vehicular loads. The steel grid at the Hoquiam River Bridge proved itself to be unsatisfactory. Within ten years after its installation, the welds securing it to the structure were breaking loose and highway maintenance personnel had to repeatedly reweld the deck. In 1961, a bridge inspector reported that 75 percent of the welds were broken. The problem was finally solved with the installation of a new and heavier deck in 1987.

The machinery and electrical systems have required periodic maintenance and repairs. The pins and bushings in the center locks were replaced and much of the electrical system was reconstructed in 1967. One of the pinion shafts and a gear failed on 17 February 1982, leaving one of the leaves stuck open for several days. After the replacement of the steel grid deck in 1987, a new problem appeared. The new roadway created an imbalance in one of the leaves, causing undue wear on the gears.[31]

The structure is a complicated one, with a variety of parts, each requiring different kinds of repairs and maintenance. Such problems will probably grow worse as the bridge advances in age.

<u>Data Limitations</u>

Several sources were helpful in preparing this report. The *Pacific Builder and Engineer's* regular "Construction News" bulletin, has several entries concerning the Hoquiam River Bridge, which helped date it and provided some information about its design development. The Washington Department of Highways' *Biennial Report* provided additional information. An article in the *Aberdeen Daily World,* found in a newspaper clipping file at the Washington State Library's Northwest Room, in Olympia, described the bridge dedication in great detail.

Several sources provided information regarding the bridge and its design. Working drawings and specifications survive at the Washington State Department of Transportation, making it possible to describe and analyze the structure. Several engineering handbooks, published in the 1910s and 1920s, discuss bascule bridges of all types, including the Strauss types. An *Engineering News-Record* article written by Philip Kaufman explained the rationale behind the centerlock used in Strauss double-leaf bridges such as the Hoquiam bridge.

Project Information

This project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States. The Washington State Historic Bridges Recording Project was co-sponsored in 1993 by HAER, the Washington State Department of Transportation (WSDOT), and the Washington State Office of Archeology & Historic Preservation. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Robert J. Kapsch, Ph.D., Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; and Dean Herrin, Ph.D., HAER Staff Historian.

The recording team consisted of Karl W. Stumpf, Supervisory Architect (University of Illinois at Urbana-Champaign); Robert W. Hadlow, Ph.D., Supervisory Historian (Washington State University); Vivian Chi (University of Maryland); Erin M. Doherty (Miami University), Catherine I. Kudlik (The Catholic University of America), and Wolfgang G. Mayr (U.S./International Council on Monuments and Sites/Technical University of Vienna), Architectural Technicians; Jonathan Clarke (ICOMOS/Ironbridge Institute, England) and Wm. Michael Lawrence (University of Illinois at Urbana-Champaign), Historians; and Jet Lowe (Washington, D.C.), HAER Photographer.

APPENDIX

The Puget Sound Bridge and Dredging Company

The Hoquiam River Bridge at Simpson Avenue is not only an example of a Strause bascule structure. It is one of the many projects built by a significant Pacific Northwest firm, the Puget Sound Bridge and Dredging Company of Seattle, and its successors.

John McMullen, a carpenter, and two engineers, George W. Catt and Herman Krusi founded the company as the San Francisco Bridge Company, in 1886. They opened a branch office in Seattle, under the name of the Puget Sound Bridge and Dredging Company, in 1889, and another branch office, in Spokane. In addition, they founded subsidiaries in New York, the Atlantic, Gulf and Pacific Company, and in Manila, the Atlantic, Gulf and Pacific Company of Manila. These different concerns eventually went their separate ways by 1905. The Lockheed Aircraft Corporation of Burbank, California acquired the company in 1959 and changed the name to the Puget Sound Bridge and Dry Dock Company. The name changed again in 1964, to the Lockheed Shipbuilding and Construction Company. Eventually the company split, with the dredging division separated as the Puget Sound Dredging Company, under the ownerehip of H. W. McCurdy, former president of the larger company.

The Puget Sound Bridge and Dry Dock Company built the Wishkah bridge (1925), the Hoqiuam River Bridge, the Lake Washington Floating bridge (1940, HAER No. WA-2), which was the first concrete pontoon bridge ever built, and the Hood Canal floating bridge. Other bridges built by the company included the Chehalis River Bridge at Aberdeen, Washington, the and the Columbia River Bridge at Brewster, Washington. The company also built a Strauss heel trunnion bascule in 1910, the Northern Pacific Railroad bridge over the Duwamish Waterway, Seattle, which was the first steel bridge in the city.[32] In addition, the firm built the nearby Spokane Street Bridge, one of several bascule bridges designed by the city of Seattle. The list includes the Columbia River Bridge at Cascade Locks, Oregon, known as "The Bridge of the Gods," and a 215' high bridge across the Dead Horse Gulch in Alaska for the White Pass and Yukon Railroad.

The firm has built numerous ships, including several destroyers, minesweepers, transports, freighters, ferries, as well as drydocks for repairing. It built many important buildings in the Seattle area, including the University of Washington football stadium, the County and City Building, commercial high rises, and apartment buildings. Its other ventures have included pulp mills, paper mills, aluminum manufacturing plants, radar installations, radio towers, and two major naval air bases in

Alaska. Its dredging operations have included the creation of Harbor Island at the mouth of the Duwamish in 1914, which at the time was the largest artificial island in the world and which is still the center of Seattle's harbor.

The Puget Sound and Bridge and Dredging Company has played a key role in many important construction projects in the Northwest. The company remains the leading engineering and contracting concern in the region and is a major employer in the Puget Sound area.[33]

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FIGURES

g = center of gravity for the leaf
g′ = center of gravity for the counter weight
P = load of the leaf
W = load of the counterweight
Px = moment about the main trunnion A
Wy = moment about the counterweight trunnion C

Px = Wy at all times.

Figure 1: Schematic diagram of the Strauss underneath counterweight bascule type. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

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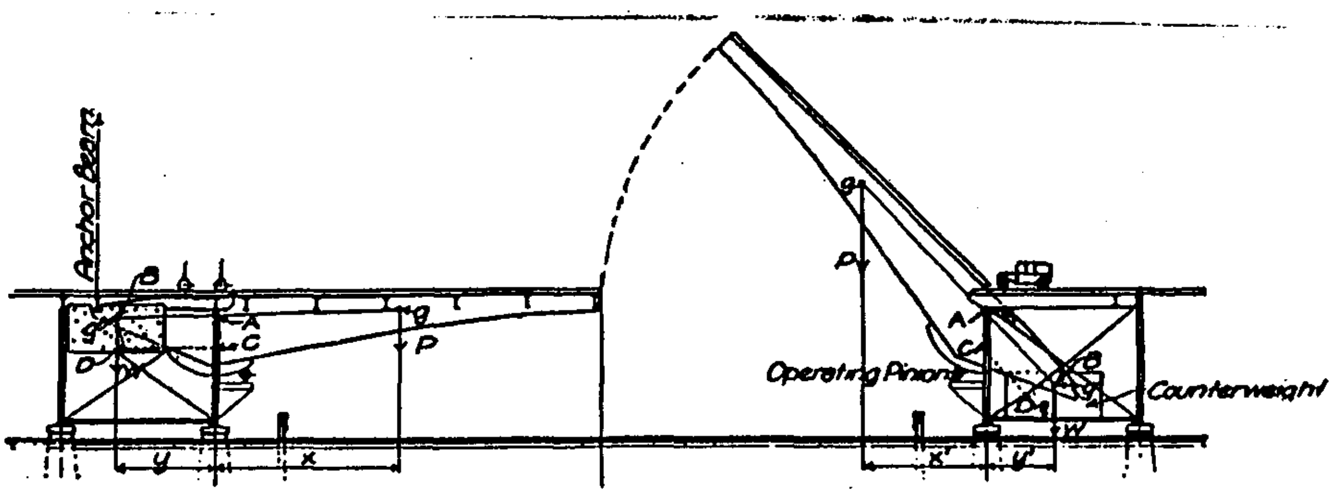
Figure 2: Schematic diagram of the Strauss overhead counterweight bascule type. From Otis Ellis Hovey, *Moveable Bridges* (New York: John Wiley & Sons, 1926).

Figure 3: Machinery layout for the Hoquiam River Bridge. From Washington Department of Highways, "Hoquiam River Bridge in Hoquiam, Grays Harbor County--Lubrication Chart" (approved May 1945).

Figure 4: Center lock at the Hoquiam River Bridge. From Wallace Bridge and Structural Steel Co., Seattle, Washington. Shop drawings for the Hoquiam River Bridge bascule span (June 1927), sheet no. 755-26.



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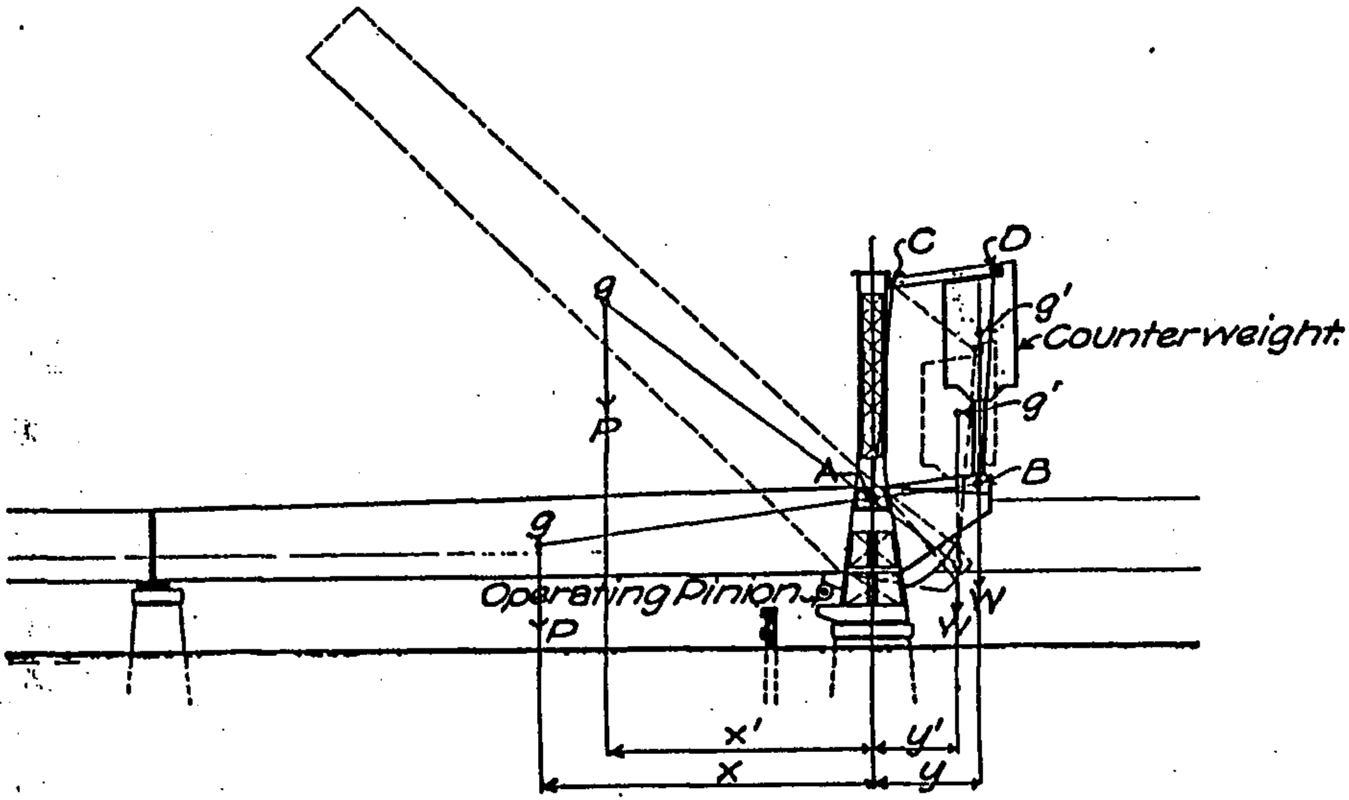

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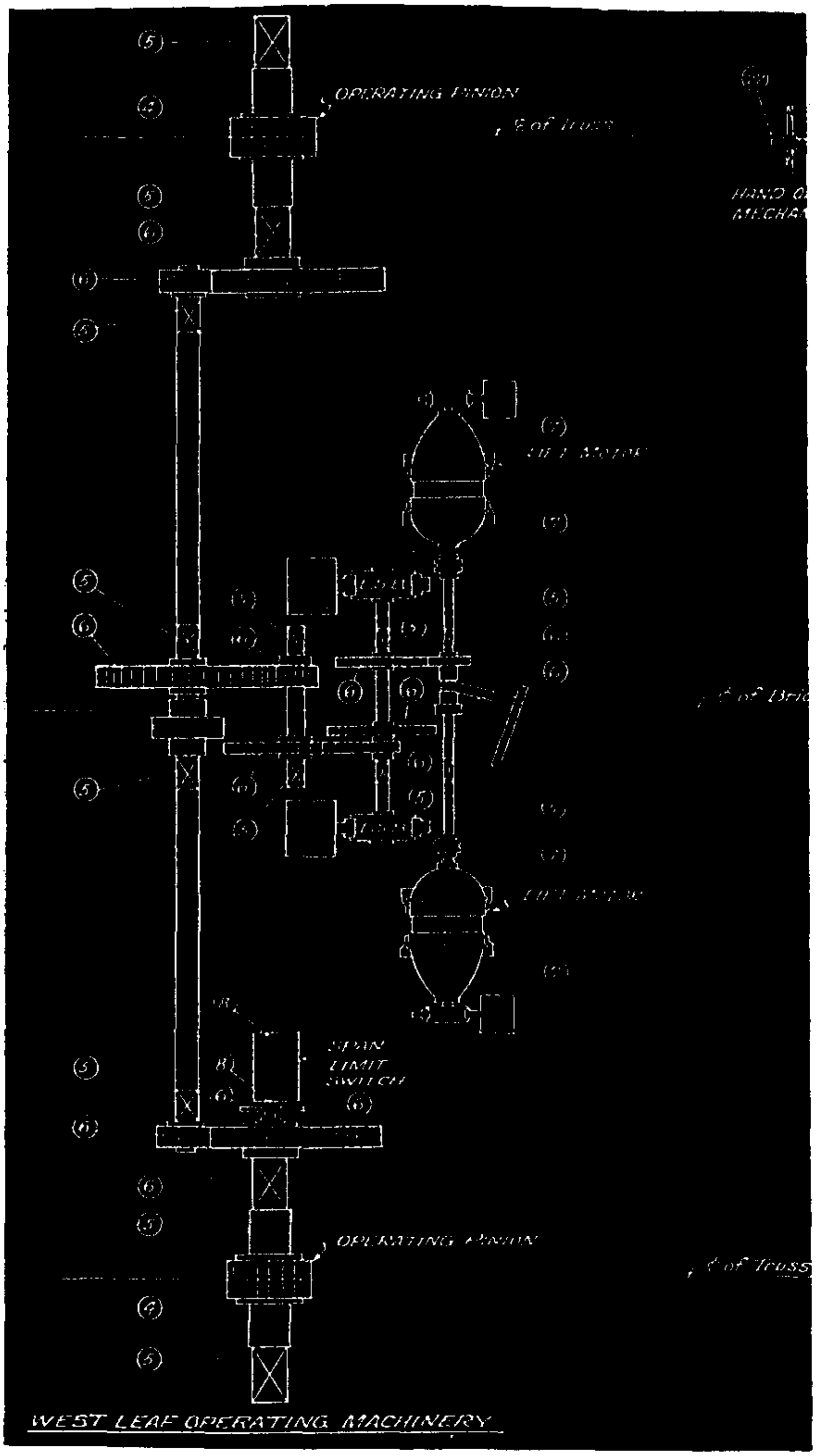

Figure 3: Machinery layout for the Hoquiam River bridge. From Washington State Highway Department, "Hoquiam River Bridge in Hoquiam, Grays Harbor County -- Lubrication Chart" (approved May

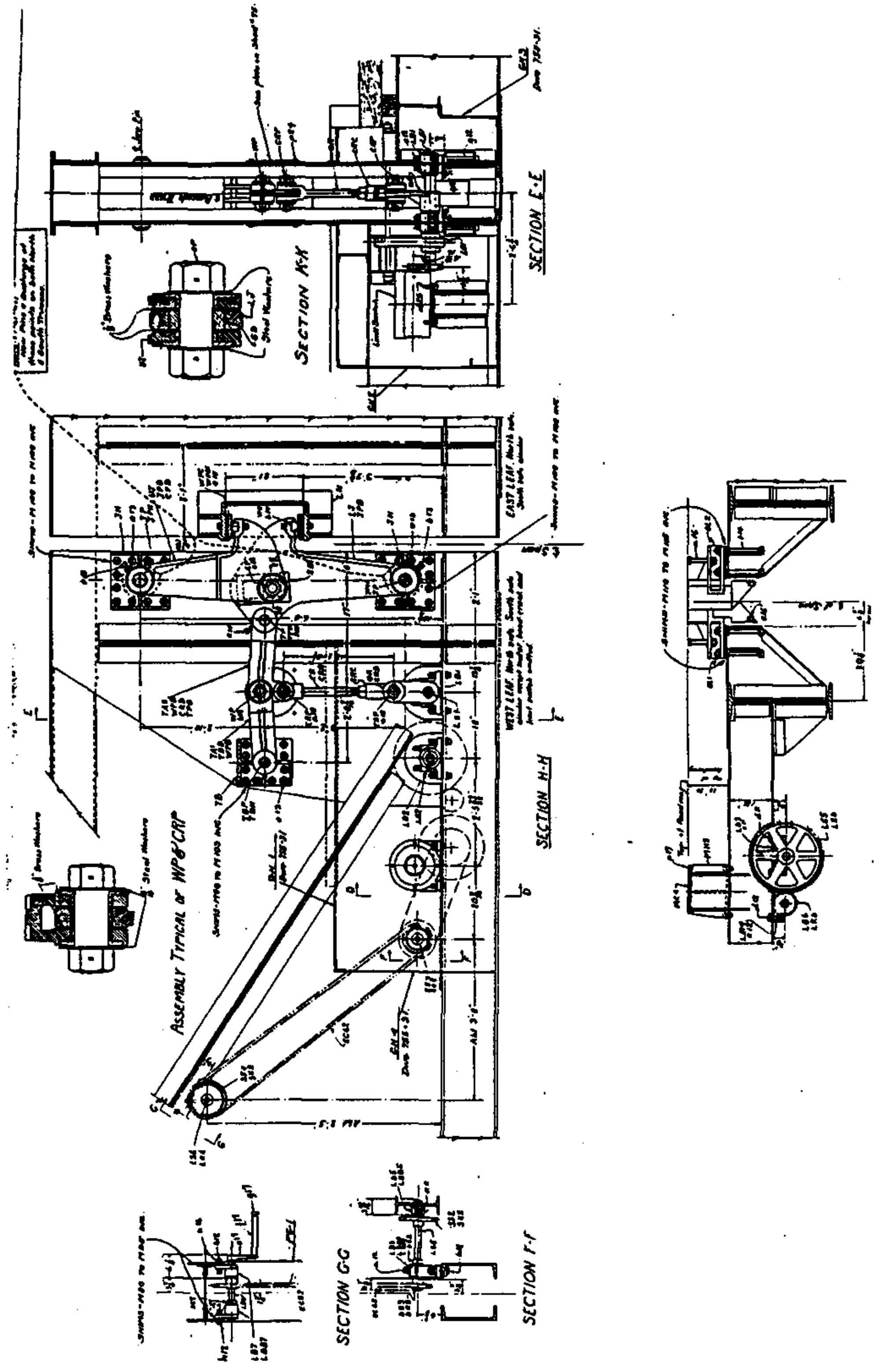

Figure 4: Center lock at the Hoquiam River bridge. From Wallace Bridge and Structural Steel Co., Seattle, Washington. Shop drawings for the Hoquiam River bridge bascule span (June 1927), sheet no. 755-26.

ENDNOTES

[1] Ade Fredericksen, "It was 1928: planes roared, throngs cheered," *Aberdeen Daily World*, 31 March 1977, A-10. Although this article was published 50 years after the bridge was dedicated, it cites and quotes articles published at the time in the *Daily World*. It includes a photograph of the bridge, with the mills next to it. Both mills are gone now.

[2] Ibid.

[3] "Construction News," *Pacific Builder and Engineer* 28 (3 November 1922): 2.

[4] "Construction News," *Pacific Builder and Engineer* 29 (20 July 1923): 2.

[5] "Construction News," *Pacific Builder and Engineer* 29 (3 August 1923): 2.

[6] "Construction News," *Pacific Builder and Engineer* 29 (29 September 1923): 13; and 30 (8 March 1924): 13.

[7] "Construction News," *Pacific Builder and Engineer* 32 (14 August 1926): 8; and 32 (21 August 1926): 8

[8] "Construction News," *Pacific Builder and Engineer* 32 (16 October 1926): 6; 32 (27 November 1926): 6; and 32 (25 December 1926): 6.

[9] Strauss Bascule Bridge Company, Strauss Bascule Bridge, Patented, over Hoquiam River at Simpson Avenue for Washington State Highway Department (Dates ranging from December 1926 to February 1927), held by Records Control, Washington State Department of Transportation, Olympia, WA [WSDOT]; Strauss Bascule Bridge Company, "Specifications for Strauss Trunnion Bascule Bridge over Hoquiam River at Simpson Avenue, Hoquiam, Washington for Washington Highway Department (1926), held by Bridge Preservation Section, WSDOT.

[10] "Construction News," *Pacific Builder and Engineer* 33 (15 January 1927): 7.

[11] "Advertisements for Bids," *Pacific Builder and Engineer* 33 (12 February 1927): 1.

[12] "Construction News," *Pacific Builder and Engineer* 33 (19 March 1927): 10. For a history of the Puget Sound Bridge and Dredging Company, see Appendix.

[13] The final estimate was for $358,098.58. The City of Hoquiam paid $228,569.50 and the state, the rest. Washington Department of Highways, *Twelfth Biennial Report of the State Highway Engineer, 1926-1928*, 71.

[14] Wallace Bridge and Structural Steel Co., Seattle, Washington. Shop drawings for the Hoquiam River Bridge bascule span (June 1927), 6 sheets of drawings. General Electric Company, Owners, manuals for electrical equipment at the Hoqiuam River bridge (1927), held by Bridge Preservation Section, WSDOT.

[15] Fredericksen, A-1 and 1-10.

[16] Washington Department of Highways, Layout Sheet, Bridge Over Hoquiam River at Hoquiam, sheet 1, approved January 1927. See also, Washington Department of Highways, *Twelfth Biennial Report of the State Highway Engineer, 1926-1928*, 71.

[17] "Layout Sheet" and Strauss Bascule Bridge Company, "Strauss Bascule Trunnion Bridge, Patented, over Hoquiam River at Simpson Avenue for Washington State Highway Department," sheet nos. 1 and 8.

[18] Strauss Bascule Bridge Company, sheet 2.

[19] In this, the Hoquiam bridge is similar to the Chicago or simple trunnion bascule type, such as the Montlake Bridge in Seattle (HAER No. WA-108).

[20] Strauss Bascule Bridge Company, sheet 2.

[21] This analysis is based, in part, on Otis E. Hovey, *Structure* vol. 1 of *Movable Bridges* (New York: John Wiley & Sons, 1926), 117-19.

[22] Or as John Alexander Low Waddell put it, "This enables the said counterweight to move parallel to itself at all times." See J. A. L. Waddell, *Bridge Engineering*, vol. 1 (New York: John Wiley and Sons, 1916), 704. See also Hovey, 116-17.

[23] Wallace Bridge and Structural Steel Co., Seattle, Washington. Shop drawings for the Hoquiam River Bridge bascule span (June 1927), sheet 775-25.

[24] Ibid., sheet 775-26.

[25] P. L. Kaufman, "New Center Lock for Double Leaf Bascule Bridges," *Engineering News-Record* 90 (8 March 1923): 467.

[26] Washington State Highway Commission, "Hoquiam River Bridge, No. 9/432, Electrical Reconstruction" (approved 24 July 1967), sheet 5, held by Bridge Preservation Section, WSDOT.

[27] Hovey, *Movable Bridges*, vol. 1, 119-21.

[28] The first Strauss bascule bridge was described in *Engineering News*, 24 November 1904.

[29] Patent No. 1,170,703. Joseph B. Strauss, Chicago, Illinois, filed 18 March 1908.

[30] Hovey, *Movable Bridges*, vol. 1, 116.

[31] "Hoquiam River Bridge, No. 9/432," Bridge Inspection Reports, in Correspondence Files, Movable Bridges, Bridge Preservation Section, WSDOT.

[32] The Northern Pacific Railway bridge in Seattle still stands.

[33] This information is taken from *71 Years of Progress* (Seattle: Puget Sound Bridge and Dry Dock Company, 1960) and Gordon Newell, "Puget Sound Bridge and Dredging Company," *Portage* 4 (Winter 1982): 11-14.